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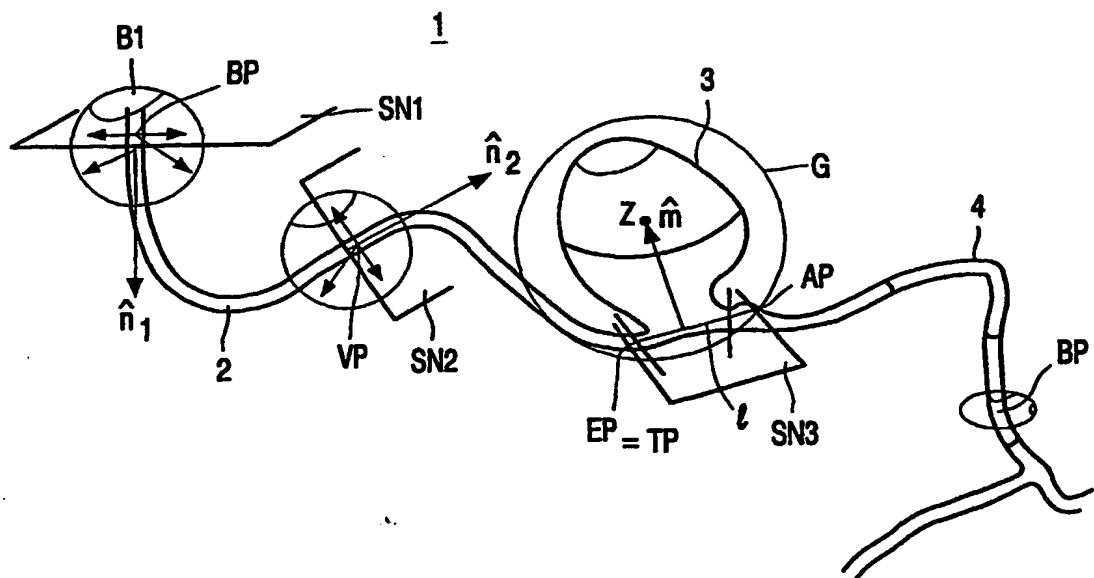
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- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ANALYSIS OF AN OBJECT DATA SET ON A MULTI-DIMENSIONAL SPACE



(57) Abstract: The method relates to analysis of a tubular structure (1) such as a rendition of the vascular system of a patient. Gradients  $g_{ij}$  to the surface of the tubular structure (1) are computed in a starting point (BP). Subsequently, a normal  $\hat{n}$  which extends essentially perpendicularly to the gradients is derived and a cross-section is taken along a cutting plane having  $\hat{n}$  as its normal. A subsequent position (VP) is taken by performing a small shift in the direction of  $\hat{n}$ . The axis of the vessel is tracked by repeating the procedure.

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Analysis of an object data set on a multi-dimensional space.

The invention relates to a method of analyzing an object data set on a multi-dimensional space.

Such an object data set represents one or more properties of the object to be examined. The object data set notably relates to the density distribution in the object to be examined; in that case the data values are the local density values of (a part of) the object to be examined. The data values may also relate, for example, to the distribution of the temperature or the magnetization in the object. The multi-dimensional space is usually the three-dimensional space. The data values then relate to a volume distribution of the relevant property, for example, the density distribution in a volume of the object to be examined. The multi-dimensional space may also be two-dimensional. In that case the data values relate to a distribution of the relevant property in a plane through the object, for example the density distribution in a cross-section through the object.

The object data set can be acquired in a variety of ways. The object data set notably relates to a patient to be examined. Such an object data set can be acquired by means of various techniques such as 3D X-ray rotational angiography, computed tomography, magnetic resonance imaging or magnetic resonance angiography.

The article "3D rotational angiography: Clinical value in endovascular treatment" in Medica Mundi 42 (1998) by J. Moret et al. concerns the determination of the section of a blood vessel.

According to the known method a more or less tubular structure relating to the blood vessel of the patient to be examined is identified from the object data set. Such an identification is performed on the basis of differences between data values relating to the blood vessel and to the surrounding tissue. Such differences are realized by introducing a suitable contrast agent into the vascular system of the patient to be examined during the acquisition of the object data set. According to the known method a cutting plane is visually taken in the object data set so as to extend more or less transversely of the tubular structure. Subsequently, the diameter of the relevant blood vessel is calculated from the cross-section of the tubular structure along the cutting plane.

It is a drawback of the known method that it is difficult to orient the cutting plane so as to extend accurately perpendicularly to the tubular structure. This inaccuracy introduces serious errors in the calculated diameter of the relevant blood vessel.

It is an object of the invention to provide a method wherein analysis of a tubular structure in the object data offers more accurate results than the known method. It is notably an object of the invention to provide a method whereby the diameter of such a tubular structure can be accurately determined.

This object is achieved according to the invention by means of a method of analyzing an object data set in which a tubular structure occurs, wherein

- 10 - said object data set assigns data values to positions in a multi-dimensional space, which data values relate to an object to be examined,
- a starting position is chosen in or near the tubular structure,
- gradients to the surface of the tubular structure are derived at the area of the starting position,
- 15 - a cutting plane is derived through the starting position so as to have a direction as parallel as possible to the gradients in positions to the surface of the tubular structure and in a vicinity of the starting position, and
- a cross-section of the tubular structure is derived along the cutting plane.

The object data set can be acquired, for example, by means of various techniques such as magnetic resonance angiography, computed tomography or 3D rotational X-ray angiography. Techniques of this kind produce an object data set with data values representing the structure of (a part of) the vascular system of the patient to be examined.

The tubular structure concerns a part of the object data set in which the data values deviate from the surroundings of the tubular structure. The deviating data values lie, for example, in a selected range of data values which are larger than a predetermined threshold or smaller than a predetermined ceiling value. The positions in the multi-dimensional space for which the data values have such a deviating value are situated in an elongate, more or less tubular region. This tubular region may be shaped as a vacated or a filled tube. The tubular structure can be indicated in the object data set by means of segmentation techniques, thus identifying the positions with the deviating data values.

The starting position indicates the position in which the cross-section of the tubular structure is desired. The starting position can be indicated, for example, by pointing it out in a rendition of the object data set on a display screen.

The gradients concern local differences between data values at the area of the surface. According to the invention the normal vector to the cutting plane is oriented exactly transversely of the gradients to the surface. The normal vector is oriented in such a manner that the normal vector is perpendicular to the gradients with a small tolerance only. The cutting plane can thus be oriented substantially parallel to the tubular structure. As a result, the diameter of the tubular structure can be accurately derived from the cross-section of the tubular structure. This diameter represents, for example, a useful technical result of the examination of the vascular system of the patient to be examined. It is notably possible to perform an accurate examination of stenoses or aneurysms.

These and other aspects of the invention will be described in detail hereinafter on the basis of the following embodiments which are defined in the dependent Claims.

The normal vector to the cutting plane is oriented, for example, by minimizing the weighted sum of the squares of the scalar products of the normal vector and the gradients to the surface of the tubular structure in a (small) vicinity of the starting position while varying the normal vector to the cutting plane. The weights in the weighted sum can be used, for example to make the effect of gradients in positions nearer to the starting point on the normal vector to the cutting plane greater than the effect of gradients in positions situated somewhat further from the starting position.

Preferably, a local center of the tubular structure in the cutting plane is derived from positions in the cutting plane having data values in the selected range. This local center represents the center of the tubular structure in the cross-section along the cutting plane. For example, the local center is situated in a position which is situated at approximately the same distance from practically all positions in the cutting plane having data values in the selected range. It has been found that in many cases the vast majority of such positions having data values in the selected range and in the cutting plane represent locations at the edge of the tubular structure. Preferably, positions in which the gradients have a magnitude greater than a minimum value are used to derive the local center. Positions at the edge of the tubular structure are thus accurately selected.

An even more accurate result for the local center is achieved iteratively by means of the method defined in Claim 4. Preferably, a subdivision into four equally large sectors is used. Positions outside the relevant tubular structure are excluded by determining the minimum distance of positions having data values in the selected range in each sector. When different minimum distances from the current center position of the local center occur

in different sectors, the current center position will not be situated exactly at the center of the tubular structure. A more accurate estimate of the center position is obtained by shifting the center position slightly in the direction of the sector in which the largest minimum distance occurs. Preferably, the center position is shifted over a distance corresponding to half the difference between the minimum distances in oppositely situated sectors.

According to the invention it is also possible to track the longitudinal axis of the tubular structure. To this end there is derived a subsequent position which is shifted in the direction of the normal to the cutting plane in the starting position. A next cutting plane through the subsequent position is then derived in conformity with Claim 1. In the next cutting plane a local center of the cross-section through the tubular structure is determined again. Successive local centers are derived along the tubular structure by repetition. The magnitude of the shift along the tubular structure can be chosen by the user. The tracking of the tubular structure will be more exact as the shifts for deriving each time a next subsequent position are smaller. Preferably, a series of diameters is calculated for the series of cross-sections through the tubular structure thus obtained along respective cutting planes. This offers a thorough insight into the variation of the diameter of the tubular structure along the longitudinal axis of the structure. This result constitutes a useful aid for examining the extent of stenosis in the vascular system of the patient to be examined.

The invention is preferably used for tracking a tubular structure which includes a reservoir whereto inlet and outlet ducts are connected. The reservoir typically has a diameter which is significantly larger than that of the inlet and outlet ducts. Such a situation occurs, for example, in the case of an aneurysm. The actual aneurysm then corresponds to the reservoir whereas the inlet and outlet ducts correspond to the blood vessels feeding and draining the blood to and from the actual aneurysm. The method disclosed in Claim 6 is preferably used in such a situation. According to the invention the inlet and outlet points can be determined by tracking the inlet and outlet ducts in conformity with Claim 5. Preferably, such tracking of the inlet and outlet ducts is observed on a monitor by the user who can terminate the tracking operation as soon as the connections to the reservoir are reached. Subsequently, a central position is determined in the reservoir. For example, a part of the object data set which contains the reservoir and a small (relative to the reservoir) number of positions outside the reservoir is selected. It has been found that the center of gravity of the data values in the selected part of the object data set suitably corresponds to the center of the reservoir. The cutting plane through the inlet and outlet points and through the center of the reservoir separates the reservoir from the inlet and outlet ducts. The volume of the reservoir

to the side of the cutting surface which faces the central position accurately represents the effective volume of the reservoir. When the reservoir with the inlet and outlet ducts represents an aneurysm and the connected blood vessels, the effective volume of the reservoir constitutes an accurate result concerning the size of the aneurysm; this is of importance for the further treatment of the aneurysm.

Preferably, the method is carried out by means of a suitably programmed workstation. For example, a computer program with instructions for carrying out the steps as defined in the Claims 1 to 7 is loaded into such a workstation.

Claim 7 defines a further application of the invention for a tubular structure with a reservoir whereto inlet and outlet ducts are connected. The inlet and outlet points are determined again by tracking the inlet and outlet ducts in conformity with Claim 5. According to this application of the invention a connection duct is interpolated between the inlet point and the outlet point and through the reservoir. Subsequently, the connection duct is isolated from the reservoir. It has been found that the remainder constitutes a good approximation of the effective reservoir which can be suitably used for determining the size of the aneurysm.

These and other aspects of the invention will be elucidated, by way of non-limitative example, with reference to the following embodiments and the accompanying drawing; therein:

Fig. 1 shows an example of an object data set with a tubular structure in which the application of the invention is indicated, and

Fig. 2 shows an example of a flow chart of the method according to the invention.

Fig. 1 shows an example of an object data set containing a tubular structure in which the application of the invention is indicated. Fig. 2 shows an example of a flow chart of the method according to the invention. Fig. 1 notably shows the tubular structure, in this case a rendition of a part of the vascular system of the patient to be examined, which has already been segmented from the possibly larger object data set. This is represented by the step 10 in Fig. 2. The segmentation consists, for example, in that all data values are set to a fixed value in positions in which the original object data set contains data values outside the selected range. The vascular system includes an aneurysm 3 which acts as a reservoir, a blood vessel 2 which transports blood to the aneurysm 3 and a blood vessel 4 via which blood is discharged from the aneurysm 3. The blood vessels 2 and 4 thus act as an inlet duct and an outlet duct. The starting point (BP) is selected by the user, for example by pointing it

out on the display screen of a workstation by means of a mouse and/or a keyboard and a cursor. Around the starting point (BP) there is taken a sphere (B1) as indicated in step 20.

The gradients ( $g_{1j}$ ) of the data values are calculated at points on the edge of the tubular structure in the sphere (B1); this is indicated in step 30. More explicitly the gradients are

5 calculated as follows:

$$g_{1j} = \begin{pmatrix} \frac{\partial D}{\partial x_j} \\ \frac{\partial D}{\partial y_j} \\ \frac{\partial D}{\partial z_j} \end{pmatrix}, \text{ where } (x_j, y_j, z_j) \text{ is the position at issue at the surface of the tubular structure and}$$

$D$  indicates the data-values of the data-set which represent for example the pixel-values or the voxel-values of the object to be examined. Consequently, the vector  $g_{1j}$  points transverse to the surface of the tubular structure. Subsequently, in step 40 the normal vector  $\hat{n}_1$  is

10 calculated by means of a minimization process, so that the sum  $\sum_j w_j (\hat{n}_1 \cdot g_{1j})^2$  is minimum. The weight factors  $w_j$  are to be adjusted by the user; preferably, the weight factors decrease as the distance between the position in which the gradient  $g_{1j}$  is calculated and the starting point BP is larger. The cutting plane SN1 has a normal vector  $\hat{n}_1$  and extends through the starting point BP. The cross-section through the tubular structure 1 along the cutting

15 plane SN1 is taken in step 50. In step 51 the local diameter  $d$  of the tubular structure 1, i.e. of the blood vessel, is derived from this cross-section. Furthermore, in step 52 the local center position of the tubular structure is derived from the cross-section by executing the iterative procedure in conformity with Claim 4.

In order to track the tubular structure as from the starting point BP, in step 60

20 the subsequent position VP is derived in the direction of the normal vector  $\hat{n}_1$  which is locally oriented accurately along the axis of the blood vessel. The magnitude of the shift is adjusted by the user in dependence on the degree of meandering of the tubular structure. Fig. 1 shows a subsequent position VP which is reached after a large number of shifts along the axis of the blood vessel 2. When the subsequent position is not yet the end position (EP) desired by the

25 user, the steps 20, 30, 40, 50, 51, 52 and 60 are repeated. Thus, the axis along the blood vessel and the diameter along the axis are thus determined.

For example, the end point EP is the inlet point TP from the blood vessel 2 to the aneurysm 3. The outlet point AP is reached by tracking the blood vessel from a different



starting point BP' on the blood vessel 4 by means of the procedure shown in Fig. 2. For example, the user himself can terminate the tracking of the blood vessel when, on the basis of the anatomical insight of the user, the inlet point or outlet point has been reached. It is also possible to terminate the tracking of the blood vessel when the local diameter of the blood vessel suddenly increases strongly. A connecting line  $l$  is drawn through the inlet point and the outlet point (TP, AP). Furthermore, the central position  $Z$  of the aneurysm 3 is calculated as the center of gravity on the basis of the data values in the region  $G$ . The region  $G$  is, for example, a sphere around the aneurysm 3. It has been found that suitable results are achieved for the center position  $Z$  when it is ensured that the region  $G$  does not include too many points in the segmented data set which lie outside the aneurysm. The normal vector  $\hat{m}$  is directed opposite to the perpendicular from  $Z$  to the connecting line  $l$ . Subsequently, a cutting plane SN3 is determined through the connecting line and with the normal vector  $\hat{m}$ . It appears that this cutting plane SN3 accurately separates the inlet and outlet ducts, in this case being the blood vessels 2 and 4, from the aneurysm 3.

## CLAIMS:

1. A method of analyzing an object data set in which a tubular structure occurs, wherein
  - said object data set assigns data values to positions in a multi-dimensional space, which data values relate to an object to be examined,
  - 5 - a starting position is chosen in or near the tubular structure,
  - gradients to the surface of the tubular structure are derived at the area of the starting position,
  - a cutting plane is derived through the starting position so as to have a direction as parallel as possible to the gradients in positions to the surface of the tubular structure and
  - 10 in a vicinity of the starting position, and
  - a cross-section of the tubular structure is derived along the cutting plane.
2. A method as claimed in Claim 1, wherein the direction of the cutting plane is derived by minimization of the sum of the squares of the scalar products of the normal vector
- 15 to the cutting plane and the gradients.
3. A method as claimed in Claim 1, wherein a local center of the tubular structure in the cutting plane is derived from positions in the cutting plane having data values within a predetermined range, such a range concerning notably data values higher than a threshold
- 20 value or data values smaller than a ceiling value.
4. A method as claimed in Claim 3, wherein the cutting plane is subdivided into a plurality of sectors and
  - a center position of the local center of the cross-section of the tubular structure
  - 25 in the cutting plane is estimated,
  - for the respective sectors a minimum distance is derived between positions having data values in the preselected range and a current estimated center position,
  - a maximum of the minimum distances in the respective sectors is determined,

- a new estimate of the center position is derived, the new estimate of the center position being shifted, relative to the current estimate, in the cutting plane in the direction of the sector in which the maximum of the minimum distances is situated and over a distance which is dependent on the differences between positions in which the minimum distances

5 occur in oppositely situated sectors,

- the steps b, c and d are repeated, if necessary, the new estimate of the center position being used each time as the current estimate.

5. A method as claimed in Claim 3, wherein

10 - a subsequent position which has been shifted, relative to the starting position, in the direction of the normal to the cutting plane through the starting position is determined, and

- a subsequent cutting plane through the subsequent position is derived, the direction of said subsequent cutting plane being as parallel as possible to the gradients in said  
15 subsequent cutting plane and to the surface of the tubular structure.

6. A method of analyzing an object data set in which a tubular structure occurs, wherein

- said object data set adds data values to positions in a multi-dimensional space,  
20 - an inlet duct, an outlet duct and a reservoir occur in the tubular structure, the inlet and outlet ducts being connected to the reservoir, and

- an inlet point is determined in the inlet duct at the area of connection of the inlet duct to the reservoir,

- an outlet point is determined in the outlet duct at the area of connection of the  
25 outlet duct to the reservoir,

- a central position of the reservoir is determined, and

- a cutting plane through the inlet and outlet points is derived, the normal to the cutting plane extending along the perpendicular from the central position to the line through the inlet and outlet points.  
30

7. A method of analyzing an object data set in which a tubular structure occurs, wherein

- said object data set adds data values to positions in a multi-dimensional space,

- an inlet duct, an outlet duct and a reservoir occur in the tubular structure, the inlet and outlet ducts being connected to the reservoir, and
  - an inlet point is determined in the inlet duct at the area of connection of the inlet duct to the reservoir,
  - 5 - an outlet point is determined in the outlet duct at the area of connection of the outlet duct to the reservoir,
  - a connecting duct is interpolated between the inlet and outlet points and through the reservoir, and
  - a remainder is derived as the difference between the reservoir and the
  - 10 interpolated connecting duct.
8. A computer programme for analysing an object data set in which a tubular structure occurs,
- the object data set assigning data values to positions in a multi-dimensional space, which
  - 15 data values relate to an object to be examined,
  - the computer programme comprising instructions for
    - choosing starting position in or near the tubular structure
    - deriving gradients to the surface of the tubular structure are derived at the area of the starting position
    - 20 - deriving a cutting plane through the starting position so as to have a direction as parallel as possible to the gradients to the surface of the tubular structure in positions in the vicinity of the starting position and
    - deriving a cross section of the tubular structure along the cutting plane.

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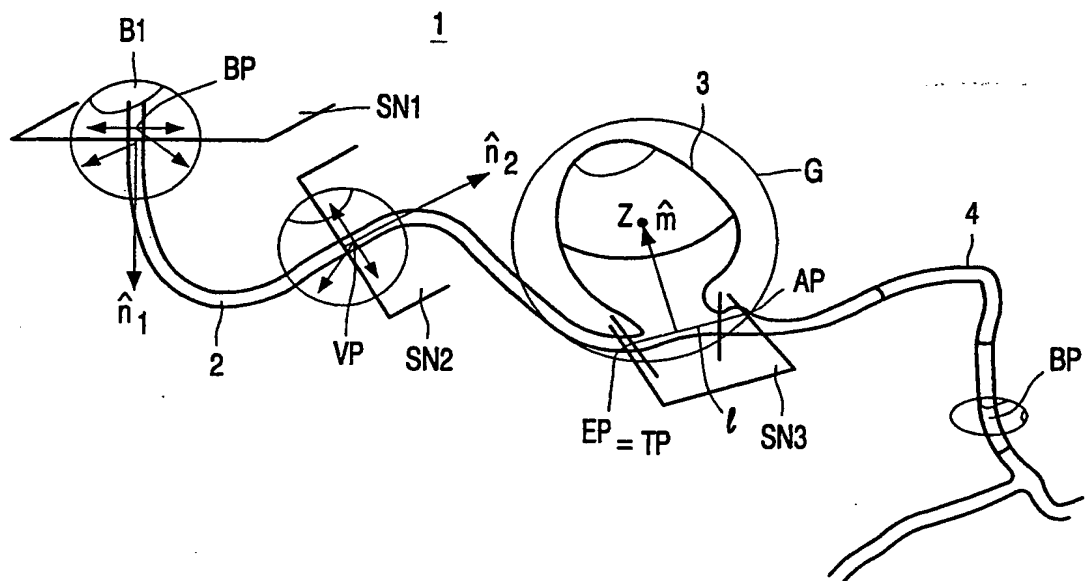


FIG. 1

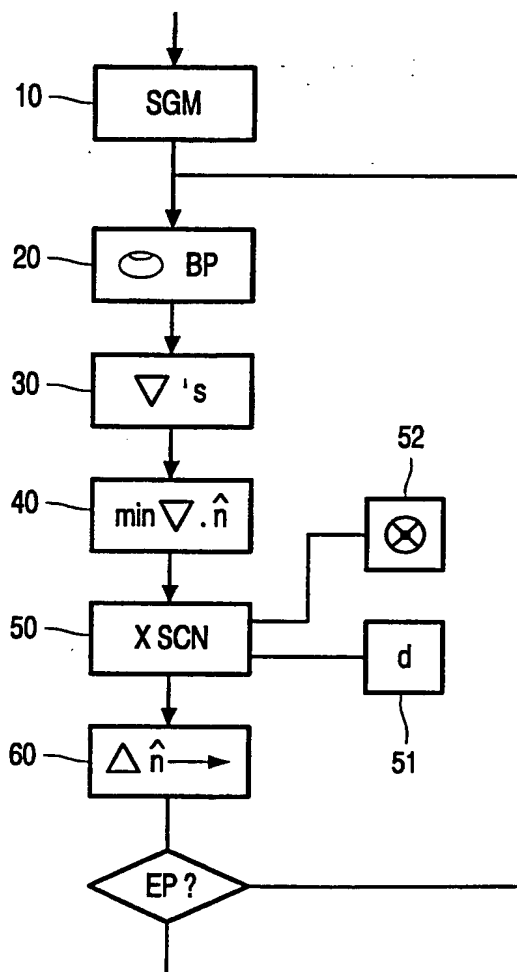


FIG. 2

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# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>PHN 17.678WO</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/EP 00/ 09505</b>	International filing date (day/month/year) <b>27/09/2000</b>	(Earliest) Priority Date (day/month/year) <b>01/10/1999</b>
Applicant <b>KONINKLIJKE PHILIPS ELECTRONICS N.V. et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 7 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

### 1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☒ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

**ANALYSIS OF A TUBULAR STRUCTURE IN MEDICAL IMAGING**

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

☐ None of the figures.

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## Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The method relates to analysis of a tubular structure 1 such as a rendition of the vascular system of a patient.

Gradients  $g_{ij}$  to the surface of the tubular structure 1 are computed in a starting point (BP). Subsequently, a normal  $\vec{n}$  which extends essentially perpendicularly to the gradients is derived and a cross-section is taken along a cutting plane having  $\vec{n}$  as its normal. This cross-section is used to iteratively evaluate the center position of the tubular structure.

A subsequent position (VP) is taken by performing a small shift in the direction of  $\vec{n}$ . The axis of the vessel is tracked by repeating the procedure. An eventual reservoir (e.g. aneurysm) is separated from the tubular structure and its volume calculated.

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# INTERNATIONAL SEARCH REPORT

ational application No.  
PCT/EP 00/09505

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

As a result of the prior review under R. 40.2(e) PCT,  
all additional fees are to be refunded.

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
  
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☒ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

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**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-5,8

tracking centre and diameter of a tubular structure (e.g. vascular system)

2. Claims: 6,7

determining the volume of a reservoir (e.g. aneurysm)  
connected to a tubular structure (e.g. vascular system)

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## INTERNATIONAL SEARCH REPORT

International Application No

P 00/09505

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G06T7/60 G06T17/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06T A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, BIOSIS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WINK O ET AL: "FAST QUANTIFICATION OF ABDOMINAL AORTIC ANEURYSMS FROM CTA VOLUMES" MEDICAL IMAGE COMPUTING AND COMPUTER-ASSISTED INTERVENTION. MICCAI. INTERNATIONAL CONFERENCE. PROCEEDINGS, 1998, XP000974692 sections 1 to 4 --- -/--	1-8

☒ Further documents are listed in the continuation of box C.☐ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*Z\* document member of the same patent family

Date of the actual completion of the international search

27 April 2001

Date of mailing of the international search report

08.05.01

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
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## INTERNATIONAL SEARCH REPORT

International Application No

P 00/09505

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>LIANG ZHOU ET AL: "THE DETECTION AND QUANTIFICATION OF RETINOPATHY USING DIGITAL ANGIOGRAMS"</p> <p>IEEE TRANSACTIONS ON MEDICAL IMAGING,US,IEEE INC. NEW YORK, vol. 13, no. 4, 1 December 1994 (1994-12-01), pages 619-626, XP000491679</p> <p>ISSN: 0278-0062</p> <p>figures 1,3</p> <p>---</p>	1-5,8
A	<p>TOLIAS Y A ET AL: "A FUZZY VESSEL TRACKING ALGORITHM FOR RETINAL IMAGES BASED ON FUZZY CLUSTERING"</p> <p>IEEE TRANSACTIONS ON MEDICAL IMAGING,US,IEEE INC. NEW YORK, vol. 17, no. 2, 1 April 1998 (1998-04-01), pages 263-273, XP000768911</p> <p>ISSN: 0278-0062</p> <p>section I</p> <p>---</p>	1-5,8
A	<p>CHUN KEE JEON ET AL: "A new approach to the estimation of diameters in coronary arteriograms"</p> <p>REAL-TIME IMAGING, DEC. 1998, ACADEMIC PRESS, UK, vol. 4, no. 6, pages 443-454, XP002157151</p> <p>ISSN: 1077-2014</p> <p>section "The Proposed Method" beginning on page 444</p> <p>---</p>	1-5,8
A	<p>DAVIES E R: "A HYBRID SEQUENTIAL-PARALLEL APPROACH TO ACCURATE CIRCLE CENTRE LOCATION"</p> <p>PATTERN RECOGNITION LETTERS,NL,NORTH-HOLLAND PUBL. AMSTERDAM, vol. 7, no. 5, 1 June 1988 (1988-06-01), pages 279-290, XP000003874</p> <p>ISSN: 0167-8655</p> <p>the whole document</p> <p>---</p>	3,4
A	<p>HASTREITER P ET AL: "Fast analysis of intracranial aneurysms based on interactive direct volume rendering and CTA"</p> <p>MEDICAL IMAGE COMPUTING AND COMPUTER-ASSISTED INTERVENTION - MICCAI'98. FIRST INTERNATIONAL CONFERENCE. PROCEEDINGS, CAMBRIDGE, MA, U, pages 660-669, XP000998229</p> <p>1998, Berlin, Germany, Springer-Verlag, Germany</p> <p>ISBN: 3-540-65136-5</p> <p>section 1, paragraph 2; sections 4 and 5</p> <p>---</p> <p style="text-align: center;">-/--</p>	6,7

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## INTERNATIONAL SEARCH REPORT

International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>VAN DER WEIDE R ET AL: "Calculating optimal angiographic angles of cerebral aneurysms" PROCEEDINGS OF COMPUTER ASSISTED RADIOLOGY AND SURGERY. CAR 97, BERLIN, GERMANY, 25-28 JUNE 1997, pages 289-294, XP000998272 1998, Amsterdam, Netherlands, Elsevier, Netherlands ISBN: 0-444-82756-0 section 4; figure 5 -----</p>	6

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